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Cold-Ray Pasteurization of Milk

Final Report No. 107

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OFFICE OF MILITARY GOVERNMENT FOR GERMANY (U.S.)
Office of the Chief of Staff

FIAT FINAL REPORT NO. 107 1 February 1946

COLD-RAY PASTEURIZATION OF MILK

BY

C. O. BALL

Joint Intelligence Objectives Agency

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FIELD INFORMATION AGENCY, TECHNICAL

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Der Preuszischen Versuchs und Forschungsandstalt
für Milchwirtschaft, Kiel, 5/9 Kronshagener Weg.

Cold-Ray Pasteurization of Milk

Cold ray pasteurization of milk represents an objective which the Institute hopes to attain with the use of an ultra-violet ray machine, invented by Siemensschuckerwerke, Siemensstadt, near Spandau, Berlin.

Sources of Information

There are only two of these machines in existence. Both are installed in the plant of Hansa Meieri Facherberger Allee, Lübeck, which produces evaporated milk and milk powder. One is a machine of small capacity; the other of a larger size which is considered feasible for commercial operation. Both machines were inspected on 30 July 1945 and again on 31 July 1945, but briefly, because of time limitations. A few rough measurements of overall dimensions were taken but all figures, as to sizes of tubes and capacities of machines, were obtained in discussions with Dr. Franz Olcenberg, Dr. Albrecht Voss, and Dr. Jan Tuenter, of Hansa Meierei, Lübeck. Between the two inspections of the machines, Prof. Dipl. Ing. Karl Plock at der Preuszischen Versuchs-und Forschungsanstalt fur Milchwirtschaft, Kiel, and Dr. Jess Christophersen, Institut für Virusforschung, Sielbeck, were interviewed.

Siemens Ultra-Violet Ray Machines:

The small machine consists essentially of a quartz tube, said to be 110 metres long in spiral form and a source of ultra violet rays. The spiral tube is approximately 1 cm. outside diameter. The diameter of the spiral is approximately 13 inches, length approximately 62 inches.

The coiled tube is mounted in horizontal position within a roughly constructed cylinder (about 24" in diameter and 70" long) of sheet metal, appearing to be either stainless steel or a white metal alloy. Ends of the enclosure are of wood. In the centre of each wooden end is a series of holes arranged in a circle of about 8" diameter.

The holes are large enough to take mercury vapour tubes having outside diameter of 8-10 mm. Four mercury vapour tubes, each about 4" longer than the enclosure of the coil, are supported horizontally in these holes. The spacing between the tubes is not uniform but is approximately so. These tubes, of course, extend through the apparatus within the coil described above. Four similar tubes, placed approximately 13" apart at the four corners of a square, extend through the apparatus outside of the coil. A rough sketch indicating the location of essential parts in end elevation is shown in Fig. 1

Connection at each end of the quartz tube coil is made by means of rubber tubing.

Milk is forced through the coil by means of a pump of rotary design.

This machine is being used commercially for vitamin D enrichment only; not for pasteurization. The modified milk product being treated has approximately 30 per cent solid content and is put through the apparatus, according to Dr. Tunter, at a rate of 200 litres per hour. It is afterwards spray dried.

In the power circuit are four transformers bearing the followintg specifications:

Type SE 50/2X1

KVA 0.1	Cycles 50
Schallgr E	Gallung ST
Volt 220	2X 1000
Ampere 0.46	0.050

Serial numbers of two of the transformers: B17845 and B17846.

The large machine is contained within a rectilinear sheet metal cabinet, having lateral dimensions of approximately 4' and 3 2/3' respectively and height of approximately 7½'. The cabinet was made by Edward Ahlborn, Hildesheim.

The tubes for liquid are arranged in three spirals, each of which is made up of 50 straight quartz tubes 2 metres long with U-tube connectors made of polyvinyl resin. The three spirals are connected in parallel to an intake manifold of 1" sanitary piping extending across the bottom of one side of the cabinet on the outside. They are likewise connected in parallel to an exhaust manifold of similar construction to the intake manifold. This extends across the bottom of the other side of the cabinet on the outside. There is a sanitary valve in each inlet pipe and each outlet pipe.

It was impossible to obtain a measurement of the tubes but Prof. Plock estimated the inside diameter as between 9 and 11 mm. and the wall thickness as between 1.5 and 2 mm. Prof. Plock said the tubes were not uniform because they were hand-drawn. The plan was to use machine-drawn tubes in future machines.

The three tubular spirals are placed side by side, slightly less than six inches apart. Between No. 1 spiral and the wall of the cabinet is a row of four mercury vapour tubes in vertical position, about 2½" from the tubes of the spiral. A similar row of four mercury vapour tubes is placed between No. 3 spiral and the opposite wall of the cabinet, as well as between spirals No. 1 and No. 2, between spirals No. 2 and No. 3, and through the centre of each spiral. Thus, there are seven rows of mercury vapour tubes - four tubes in each row.

A rough sketch indicating the locations of essential parts in end elevation is shown in Figure 2. A rough sketch of the plan of the machine, showing essential parts, is shown in Figure 3.

Liquid is fed to the machine through a rotary milk pump. Milk has never been passed through the machine. In a mechanical test with water, with the inlet and outlet valves wide open, the flow was 1200 litres/hour when gauge pressure at the intake manifold was six atmospheres.

When the machine was shipped by Siemens-Schuckertwerke to Hansa Meierei, the transformers were damaged by water and at the time of this investigation they were in Hamburg for repairs. It was expected that the repairs would be completed by about August 4, 1945.

Use of Small U-V Machine

The large ultra-violet ray machine is to be a part of a new production system for modified milk in powdered form. This product is now being enriched with vitamin D by passing the liquid concentrate of approximately 30 per cent total solids content through the small machine, thus imparting vitamin D immediately preceding the spray drying operation. This is accomplished by passing the liquid through the coil at a rate of 200 litres per hour.

Considering the internal diameter of the quartz tube to be 7 mm on the average, the liquid capacity of the 110 metres of tube in the coil would be 4.23 litres. The length of exposure of the product to ultra violet rays in the machine, therefore, would be 1.26 minutes, at 200 l/h.

The modified milk is prepared as follows: (information from Dr. Oldenberg and Dr. Tuenter.)

The basis material is formed by first mixing 1.3 parts of skimmed milk (0-0.02% fat) with 2.7 parts of whey (0-0.05% fat). Sufficient cream is added to bring fat content to 3 per cent. From three additional parts of whey, the albumen is extracted by adding from ½ to 1 per cent calcium chloride ($CaCl_2$), heating, filtering and washing with cold water. The extract has about 12% solids. This is added to the above mixture of skimmed milk, whey and cream. The analysis of the mixture is shown in Table 1.

TABLE 1 (composition of modified milk before addition of milk sugar)

Fat	3 per cent
Casein	0.9 " "
Albumen	1.3 " "
Milk sugar	4.5 " "
Ash	0.75 " "

To this mixture milk sugar is added to increase the milk sugar content from 4.5 to 7.4.

Dr. Tuenter stated that before the addition of albumen and milk sugar, the preparation is condensed by evaporation to 40 per cent total solids. The composition of the mixture which was obtained from the records, however, seems to be solely on the basis of the unconcentrated material. Dr. Tuenter stated that the addition of albumen and milk sugar results in a reduction in total solids content to 30 per cent.

This liquid containing 30 per cent solids is irradiated with ultra-violet at monochromatic rays of wave length 2537 A° by passing through the small quartz tube coil machine at a rate of 200 litres/hour; then is powdered by the spray method.

The powder is said to contain 250 I.U. vitamin D per 100 gms. on the basis of bio-assay with rats, and to have the composition shown in Table 11.

TABLE 11 (composition of modified milk powder)

Fat	22.2%	Milk Sugar	54.1%
Casein	6.5	Ash	5.4
Albumen-Globulin	9.8	Water	2.0

The pH of the powder is 6.5.

A sour mix powder also is produced which is identical to the above except that the liquid mixture is soured with lactis Clemoris to pH 4.6 before irradiating and drying.

At the present time, milk sugar cannot be obtained for use in this product and highly refined wheat starch has been substituted. The starch is added at about 25% solids.

The analysis of the mixture, on the before-concentration basis, after the addition of fat, protein, and starch, is as shown in Table 111.

TABLE 111 (composition of modified milk with wheat starch added)

Fat	3.0 per cent	Milk Sugar	4.9 per cent
Casein	0.9	Wheat starch	2.5
Alb.-globulin	1.3	Ash	0.75

In caloric-content, this material is identical to that to which milk sugar is added. Caloric content is shown in Table 1V.

TABLE 1V (Caloric-content per 100 grams of modified milk mixture on the Before-Concentration basis)

Per cent	Name of Ingredient	Calories/ 100 gm.
2.2	proteins	9.45
3.0	fat	27.0
7.4	milk sugar	28.97
	total	63.42 cal/ 100 gm.

Use of Large U-V Machine

The large machine has been tested only for mechanical operation by pumping water through the milk tubes. The efficacy of the machine for either vitamin D fortification or pasteurization is unknown. It is planned to use the machine for vitamin D enrichment only in a new large scale spray-drying line which is now being installed. It is planned to employ rays of the same characteristics as those in the small machine.

Efficiency of Small Machine as a Pasteurizer

A progress report, undated, of the Bacteriological Institute of the Preuszischen Versuchs - und Forschungsanstalt für Milchwirtschaft, Kiel, makes the following announcement in regard to studies with the ultra-violet ray machine.

"1. Research on cold pasteurization of milk by means of ultra-violet rays. (Lembke, Rickert, Thomsen, Christophersen)

"Results: Almost complete sterilization of the milk was attained, whereby the milk would keep approximately 24 hours longer. Both sporeforming proteolytic bacteria and all pathogenic organisms could be positively destroyed.

"Modified milk is soured by milk souring bacteria. The taste change can be regarded as insignificant.

"Enrichment with vitamin D proceeds simultaneously. The ultra-violet rays were generated in mercury vapour lamps.

"2. Examination of the Lethal effect of ultra-violet rays. (Lembke. Christophersen)

"It appears that lethal effect in the main is limited to a definite wave length in the ultra-violet spectrum. The effects that lead to cell destruction are to be seen in an injury of the enzyme complexes of the bacteria.

"3. Production of Baby Food upon a Whey Foundation is Combination with Cold Pasteurization. (Lembke, Plock in collaboration with the firm of Siemens-Schuckertwerke A.G. and the Hansa-Meierei, Lübeck)

> "The food closely resembles human milk in composition. In order to attain the extremely low moisture and high fat content, milk, whey and cream are mixed, cold pasteurized, and dried by the spray method.
> "Results: Complete sterilization; high vitamin D content and prominent benefits for infants."

Neither Prof. Plock nor Dr. Christophersen is intimately acquainted with the procedures and results of the bacteriological tests that were made by Prof. Lembke in studying the pasteurizating efficiency of the ultra-violet ray machine and which, according to Prof. Plock, extended over a period of more than a year. Prof. Plock's principal interest is engineering and Dr. Christophersen's work in the Bacteriological tests. They were able to give certain information about the tests, however.

Among the microorganisms used in the tests as inocula for the milk were the non-spore formers, Escherichia coli, E. typhosa and M. tuberculosis and the spore-former, B. subtilis.

Subtilis seemed to be more easily destroyed by the rays than did the non-spore formers. At times, the milk appeared to be rendered completely sterile. The results, however, are not considered to be sufficiently definite and consistent to justify a statement that the efficacy of the U-V method for pasteurization has been proved. At any rate a procedure which could be utilized with confidence in pasteurizing milk by means of ultra-violet rays has not been worked out.

The most serious obstacle to practising pasteurization of milk lies in the failure to provide a means of assuring that every particle of the milk is in contact with the walls of the exposed quartz tube for a sufficient length of time to enable the rays to destroy the dangerous microorganisms contained therein. Presumably the attainment of this objective can be promoted in only two ways, either allowing sufficient length of time to ensure the necessary exposure to all particles of milk without greater turbulence than is provided at present or to provide a means for increasing the amount of turbulence in the stream of milk while passing through the quartz tubing. Whether or not the latter step would be helpful or not is still an unanswered question.

It would seem that a large amount of fundamental work remains to be done in developing a means of providing positive control of the factor discussed above. A reasonable judgment as to the amount of work involved cannot be passed until the data on the experiments that have been conducted can be studied.

All existing records of those experiments are said to be in the hands of Prof. Andreas Lembke, who is detained in Tönsheide near Neumünster. Dr. Voss of Hansa Meierei, Lübeck, stated that Prof. Lembke is at present engaged in completing those records.

Dr. Christophersen, in discussing the effect of U-V upon spores, stated that the growth of the spores may have been merely inhibited. As far as could be revealed by the microscope, the physical form of the spores was not changed by the treatment. Dr. Christophersen thought, however, that the intensity of the U-V energy could be increased to the point at which physical destruction would take place. Whether or not serious impairment of flavour of the milk would occur at the same time appears not to be known. It was stated that the wave length that is being used, 2537 A°, produces less change of flavour than other wave lengths.

The amount of butter fat in the milk was said to have no appreciable effect upon the results obtained. Either whey or cream of approximately 16 per cent butter fat gave approximately the same results as milk having about 3 per cent butter fat, such as was generally used in the experiments.

Insofar as could be learned, the recovery of viable organisms in the milk following the tests was accomplished, first, by incubating, without transferring, for 48 hours at both 30° and 37° C, and second, by sub-culturing in broth covered with paraffin in tubes for 14 days.

Dr. C. stated that no effect other than that of U-V contributes to the pasteurization. Temperature of the milk in the pasteurizer was 10-15°.

Voltage applied to the mercury vapour tubes was thought to be 1000 v.

Prof. Plock stated that the heat pasteurizing apparatus used as a control machine in testing the U-V apparatus was a tubular, continuous-type, pasteurizer, in which the milk was heated for 43.9 seconds. This apparatus is described in a booklet, entitled "Der 'Normalerhitzer' als Grundlage für die Prüfung von Milcherhitzungsapparaten. (Entwicklung und Konstruktion.) ' by Plock and Wülzholz. Published in 1936.

In addition to the above mentioned booklet and the progress report of which a portion was transcribed on pages 7/8 of this report, two reports containing bacteriological data obtained in 1937-38 on various types of high temperature short time pasteurization operations were obtained from Dr. Plock.

These titles are as follows:-

(a) Bericht des Prüfungsamtes für Milchwirtschaftliche Maschinen, Apparate, Geräte und Anlagen der Preusz. Versuchs-und Forschungsanstalt fur Milchwirtschaft in Kiel über die Prüfung des Astra-Spiral-Trommelerhitzers Type DT fur 750 l/h der Firma Bergedorfer-Eisenwerk, Hamburg-Bergedorf, als Hocherhitzer. (Tests Nov. 25, 1937 to May 17, 1938.

(b) Bericht des Prüfungsamtes fur Milchwirtschaftliche Maschinen, Apparate, Geräte und Anlagen des Preusz. Versuchs- und Forschungsanstalt fur Milchwirtschaft in Kiel über die Prufung des Plattenerhitzers Astra Type P6 in Schaltung als Kurzzeiterhitzers mit Plattenheiszhalter für 1000 l Nennstundenleistung der Firma. Bergedorfer Eisenwerk, Hamburg-Bergedorf (Tests Sept. 30, 1937 to Oct. 19, 1938)

> (Note: This report (page 19) contains data on tests of the apparatus used as control for the tests of the U-V pasteurization effect).

(c) Die Vorschriften über die Mitcherhitzung und Ueberwachung der Molkereien (mit Erlauterungen und Abbilbungen) 1939. von Seelemann und Plock.

Item (c) apparently is the foundation for a code of rigid Federal regulations on sanitary control of the production and distribution of fluid milk and cream, which Prof. Plock stated are rigidly enforced throughout Germany.

The booklets listed above were all published before the war. The copies obtained during this investigation have been forwarded to the Joint Intelligence Objectives Agency in Washington.

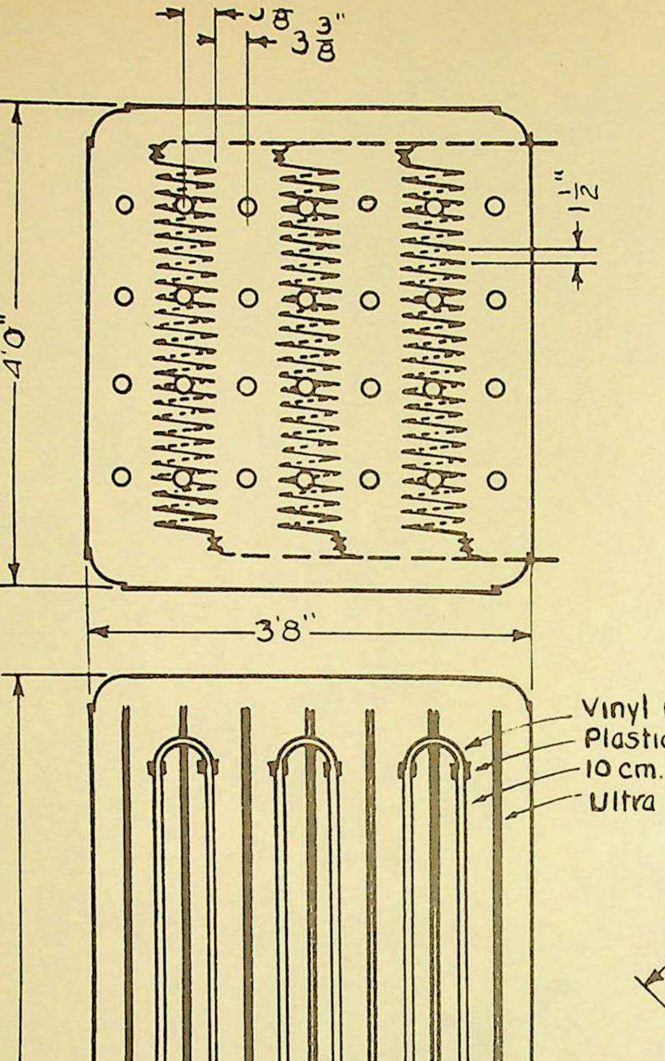
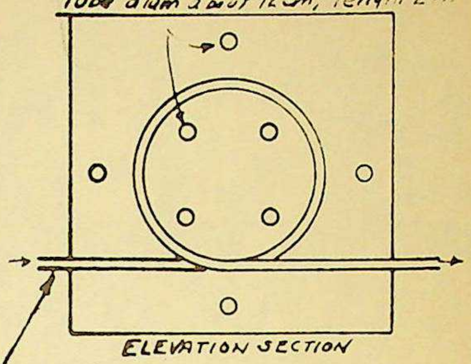


Fig. 2 Plan and Elevation of Large Machine.

Ultra violet tubes
·Wave length 2250 A°
Tube diam about 12 cm, length 2 m



Milk tube, quartz, 10 mm diam., 110 m. long. Coil diam. about 30 cm. Milk rate 300 liters/hr. Coil length about 1.8 m.

PILOT MILK IRRADIATOR
AT HANSA MEIEREI, LUBECK

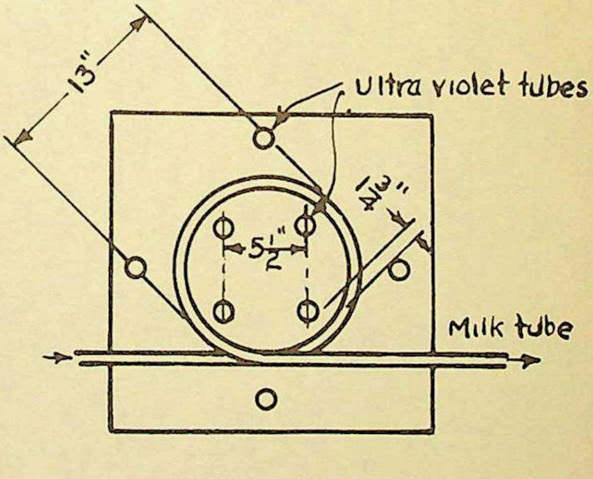
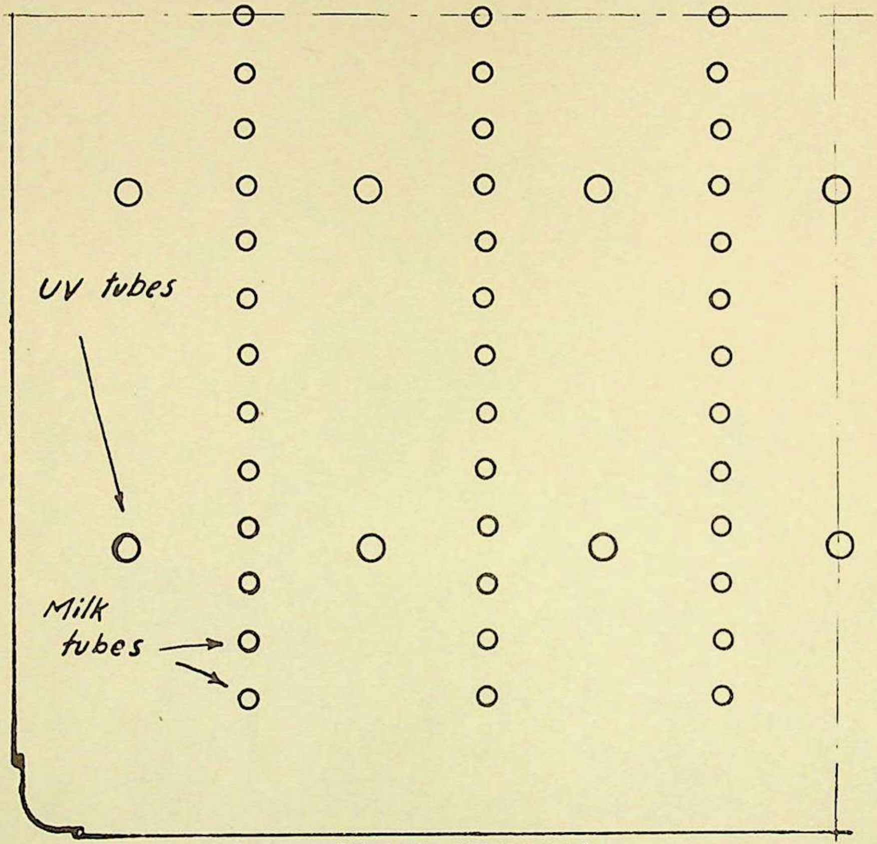


Fig. 1 Elevation of Small Pilot Unit.

R L Perry
Aug 10 '45.



PLAN SECTION

Milk tubes 10mm. diam., 2 m long, 50 tubes in each bank, 3 banks. Return bends of vinyl plastic tubing. Milk rate 400 liters/hr in each bank. UV tubes as in pilot unit.

FULL SCALE MILK IRRADIATOR., SIEMENS SCHUCKERT,
AT HANSA MEIEREI, LUBECK

RLBerry Aug 1 '45